JC07 Rec'd PCT/PTO 20 FEB 2002

FORM PTO-1390 (REV. 11-2000) U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER: 31812-178428

U.S. APPLICATION NO. (If known, see 37 CFR 1.5): 10/069003

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/EP00/07929	August 14, 2000	August 20, 1999

TITLE OF INVENTION
INDUCTION-TYPE ELECTRIC MACHINE

APPLICANT(S) FOR DO/EO/US
Peter EHRHART and Götz HEIDELBERG

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. ☐ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☐ is attached hereto (required only if not communicated by the International Bureau).
   b. ☒ has been communicated by the International Bureau. (attach form IB 308)
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☒ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4)
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)).
   a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☒ An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.
14. ☐ A SECOND or SUBSEQUENT preliminary amendment.
15. ☒ German-language International Preliminary Examination Report and Annexes
16. ☐ A change of power of attorney and/or address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
18. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. ☒ Other items or information: 2 Sheets of Formal Drawings, Figs. 1-3 as originally filed, Submission of Formal Drawings Transmittal Sheet with 2 sheets of formal drawings Figs. 1-3 with amended Fig. 1, Request for Approval of Drawing Changes with amended Fig. 1 with PCT/ISA/217 and letter from client requesting submission of amended drawing Fig. 1

20a. ☒ **For purposes of examination, please insert the annexes to the IPER, so that the application will comprise the following pages of the English translation:**
Specification: Original pages 1-12 Amended pages
Claims: Original claims Amended claims 1-14 on translated pages 1-3 of annex to the IPER

JC13 Rec'd PCT/PTO 20 FEB 2002

U.S. APPLICATION NO. (if known, see 37 CFR 1.5) 10/069003	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER

21. ☒ The following fees are submitted:

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5):

Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO $1040.00

International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO $890.00

International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO $740.00

International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) $710.00

International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) $100.00

	CALCULATIONS PTO USE ONLY	
ENTER APPROPRIATE BASIC FEE AMOUNT =	$890.00	
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	
Total claims	- 20 =		**x $18.00**	$
Independent claims	- 3 =		**x $84.00**	$
MULTIPLE DEPENDENT CLAIMS(S) (if applicable)			**+ $280.00**	$

TOTAL OF ABOVE CALCULATIONS =	$890.00	
☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2. +	$	
SUBTOTAL =	$890.00	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)).	$	
TOTAL NATIONAL FEE =	$890.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +	$	
TOTAL FEES ENCLOSED =	$890.00	
	Amount to be refunded:	$
	charged:	$

a. ☒ A check in the amount of $890.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of $ _____ to cover the above fees.

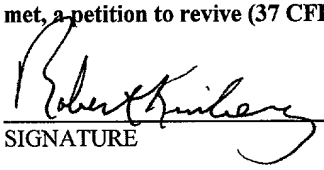
c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 22-0261. A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

VENABLE
P.O. Box 34385
Washington D.C. 20043-9998
Phone No. 202-962-4800
Fax No. 202-962-8300



SIGNATURE

Robert Kinberg
NAME

26,924
REGISTRATION NUMBER

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:
Peter EHRHART et al.

Intl. Appl. No.: PCT/EP00/07929

Art Unit: Unassigned

Examiner: Unassigned

Intl. Filing Date: August 14, 2000

Atty. Docket No.: 31812-178428

For: INDUCTION-TYPE ELECTRIC MACHINE

Customer No.

26694

PATENT TRADEMARK OFFICE

Preliminary Amendment

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

Prior to calculation of the fees, please amend the claims attached to the specification as follows:

Claim 5 (amended) A reluctance electric machine according to claim 2, characterized in that there are provided several coolant supply means and several coolant discharge means for the enclosure.

Claim 6 (amended) A reluctance electric machine according to claim 1, characterized in that the stator teeth (12) have internal flow passages (34) for the cooling medium.

Claim 7 (amended) A reluctance electric machine according to claim 1, characterized in that, with respect to the axis of rotation of the electric machine (2), the stator part (4) is arranged farther radially inside and the rotor part (6) with its rotor poles (20) is arranged farther radially outside.

Claim 8 (amended) A reluctance electric machine according to claim 1, characterized in that, with respect to the axis of rotation of the electric machine, the stator part with its stator teeth is arranged farther radially outside and the rotor part is arranged farther radially inside.

Claim 9 (amended) A reluctance electric machine according to claim 1, characterized in that the stator part (4), on the side directed away from the rotor part (6), has a design (42) for increasing the heat dissipation.

Claim 10 (amended) A reluctance electric machine according to claim 1, characterized in that the coil windings (24), in the winding head portions (38) located on the face side of the stator teeth (12), are formed with flow passages for the cooling medium that are left free between coil winding conductors.

Claim 11 (amended) A reluctance electric machine according to claim 1, characterized in that the coil windings (24) of the stator part (4) are designed as individual coils that are not interlinked with respect to the magnetic flux.

Claim 12 (amended) A reluctance electric machine according to claim 1, characterized in that a first, internal cooling circuit for circulating the cooling medium and a second, external cooling circuit for circulating another cooling medium are provided, the latter being connected to the internal cooling circuit via a heat exchanger.

Claim 14 (amended) A reluctance electric machine according to claim 12, characterized in that the internal cooling circuit and the heat exchanger are integrated in terms of space on the reluctance electric machine.

REMARKS

This Preliminary Amendment is made to eliminate multiple claim dependency. Examination on the merits of the application is requested. A marked up version showing the changes made to the claims is attached.

Respectfully submitted,

Date: 2/20/02

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RK/rgf
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VERSION WITH THE MARKING TO SHOW CHANGES MADE

Claim 5 (amended) A reluctance electric machine according to [any of claims 2 to 4] claim 2, characterized in that there are provided several coolant supply means and several coolant discharge means for the enclosure.

Claim 6 (amended) A reluctance electric machine according to [any of claims 1 to 5] claim 1, characterized in that the stator teeth (12) have internal flow passages (34) for the cooling medium.

Claim 7 (amended) A reluctance electric machine according to any of [claims 1 to 6] claim 1, characterized in that, with respect to the axis of rotation of the electric machine (2), the stator part (4) is arranged farther radially inside and the rotor part (6) with its rotor poles (20) is arranged farther radially outside.

Claim 8 (amended) A reluctance electric machine according to [any of claims 1 to 6] claim 1, characterized in that, with respect to the axis of rotation of the electric machine, the stator part with its stator teeth is arranged farther radially outside and the rotor part is arranged farther radially inside.

Claim 9 (amended) A reluctance electric machine according to [any of claims 1 to 8]claim 1, characterized in that the stator part (4), on the side directed away from the rotor part (6), has a design (42) for increasing the heat dissipation.

Claim 10 (amended) A reluctance electric machine according to [any of claims 1 to 9] claim 1, characterized in that the coil windings (24), in the winding head portions (38) located on the face side of the stator teeth (12), are formed with flow passages for the cooling medium that are left free between coil winding conductors.

Claim 11 (amended) A reluctance electric machine according to [any of claims 1-10]claims 1, characterized in that the coil windings (24) of the stator part (4) are designed as individual coils that are not interlinked with respect to the magnetic flux.

Claim 12 (amended) A reluctance electric machine according to [any of claims 1 to 11]claim 1, characterized in that a first, internal cooling circuit for circulating the cooling medium and a second, external cooling circuit for circulating another cooling medium are provided, the latter being connected to the internal cooling circuit via a heat exchanger.

Claim 14 (amended) A reluctance electric machine according to [claim 12 or 13] claim 12, characterized in that the internal cooling circuit and the heat exchanger are integrated in terms of space on the reluctance electric machine.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: Peter EHRHART et al.	
	Art Unit: Unassigned
Intl. Appl. No.: PCT/EP00/07929	Examiner: Unassigned
Confirmation No.	
Intl. Filing Date: August 14, 2000	Atty. Docket No.: 31812-178428
For: INDUCTION-TYPE ELECTRIC MACHINE	Customer No. 26694 PATENT TRADEMARK OFFICE

Request For Approval of Drawing Changes

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

Pursuant to the provisions in 37 C.F.R. § 1.121(d), Applicant requests approval of the drawing changes shown in red ink for Figure 1 on the attached sheet.

A corresponding amendment was submitted on February 5, 2001, in the international phase (copy enclosed). The amendment was accepted by the EPO as the rectification of an obvious error. See the enclosed copy of EPO Communication dated March 21, 2001. The EPO failed, however, to make the amended drawing sheet 1 of 2 part of the Annexes to the

International Preliminary Examination Report.

Respectfully submitted,

Date: 2/20/02

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RK/rgf
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FIG.1

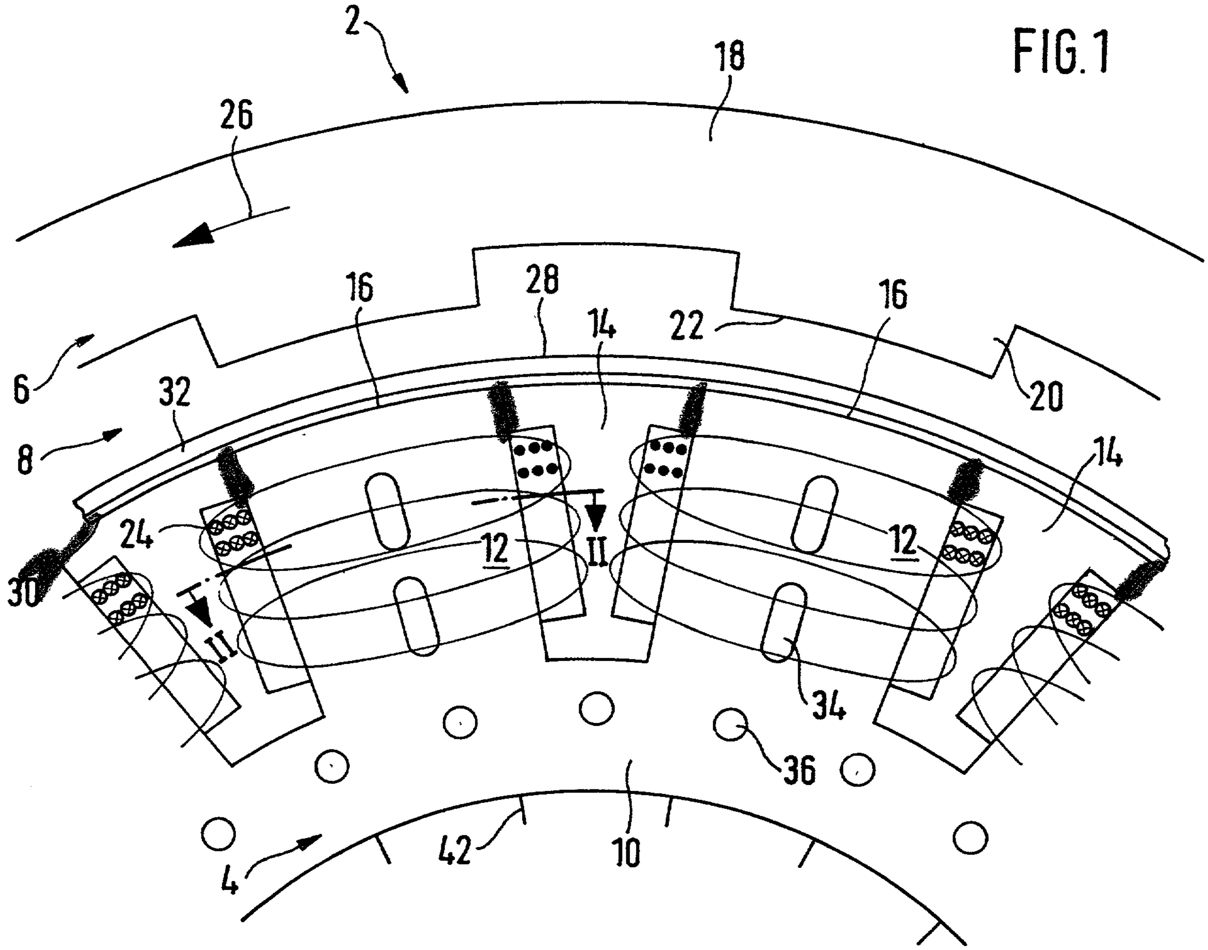
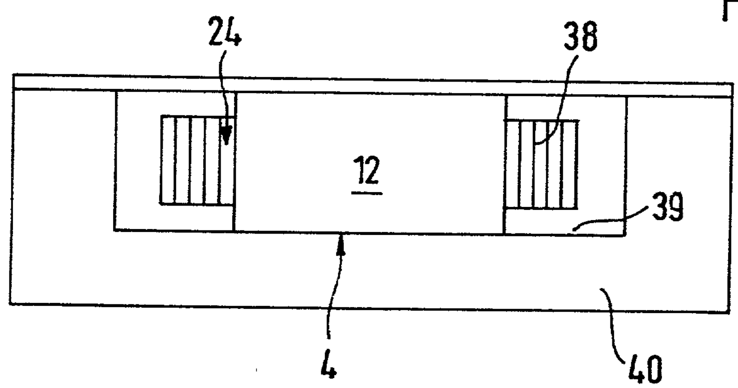


FIG.3



VERTRAG ÜBER DIE INTERNATIONALE ZUSAMMENARBEIT AUF DEM GEBIET DES PATENTWESENS

Absender: INTERNATIONALE RECHERCHENBEHÖRDE

PCT

An
KLUNKER, SCHMITT-NILSON, HIRSCH
Winzererstrasse 106
D-80797 München
GERMANY

EINGEGANGEN
22. März 2001
DR. KLUNKER
DR. SCHMITT • NILSON • HIRSCH

MITTEILUNG DER ENTSCHEIDUNG
ÜBER DEN ANTRAG AUF BERICHTIGUNG

(Regel 91.1f)PCT)

Aktenzeichen des Anmelders oder Anwalts K 51 550/8	Absendedatum *(Tag/Monat/Jahr)* 21/03/2001
Internationales Aktenzeichen PCT/EP 00/07929	**ANTWORT FÄLLIG** ENTFÄLLT Siehe aber letzter Absatz unten
Anmelder MAGNET-MOTOR GESELLSCHAFT ...	Internationales Anmeldedatum *(Tag/Monat/Jahr)* 14/08/2000

Dem Anmelder wird mitgeteilt, daß die Internationale Recherchenbehörde seinen Antrag auf Berichtigung offensichtlicher Fehler in der internationalen Anmeldung / in anderen vom Anmelder bei dieser Behörde eingereichten Schrifstücken geprüft und entschieden hat,

1. [X] der Berichtigung zuzustimmen:

   [X] wie vom Anmelder beantragt.

   [ ] im nachstehend angegebenen Umfang*:

2. [ ] die Berichtigung aus folgenden Gründen ganz oder teilweise abzulehnen*:

Ein Exemplar dieser Mitteilung ist zusammen mit einer Kopie des vom Anmelder eingereichten Antrags auf Berichtigung dem Anmeldeamt und dem Internationalen Büro übermittelt worden.

* **Wird die Berichtigung ganz oder teilweise abgelehnt,** so kann der Anmelder das Internationale Büro vor Abschluß der technischen Vorbereitungen für die internationale Veröffentlichung und unter Entrichtung einer Gebühr auffordern, den Berichtigungsantrag zusammen mit der internationalen Anmeldung zu veröffentlichen. Siehe hierzu Regel 91.1f), dritter und vierter Satz, sowie - zur Höhe der Gebühr - PCT-*Leitfaden für Anmelder,* Band I/A, Anlage B 2 (IB).

Name und Postanschrift der Internationalen Recherchenbehörde Europäisches Patentamt, P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Bevollmächtigter Bediensteter Peggy Frenzel

KLUNKER · SCHMITT-NILSON · HIRSCH

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An das
Europäische Patentamt
Erhardtstraße 27

80298 München

PATENTE · MARKEN · DESIGNS · LIZENZEN

IHR ZEICHEN/YOUR REF:	UNSER ZEICHEN/OUR REF:	TAG/DATE:
	K 51 550/8 TA-bl	05.02.2001

BETR./RE:

PCT/EP00/07929
Magnet-Motor Gesellschaft für magnetmotorische Technik mbH

Anliegend wird eine korrigierte Zeichnungsseite mit Figuren 1 und 3 eingereicht.

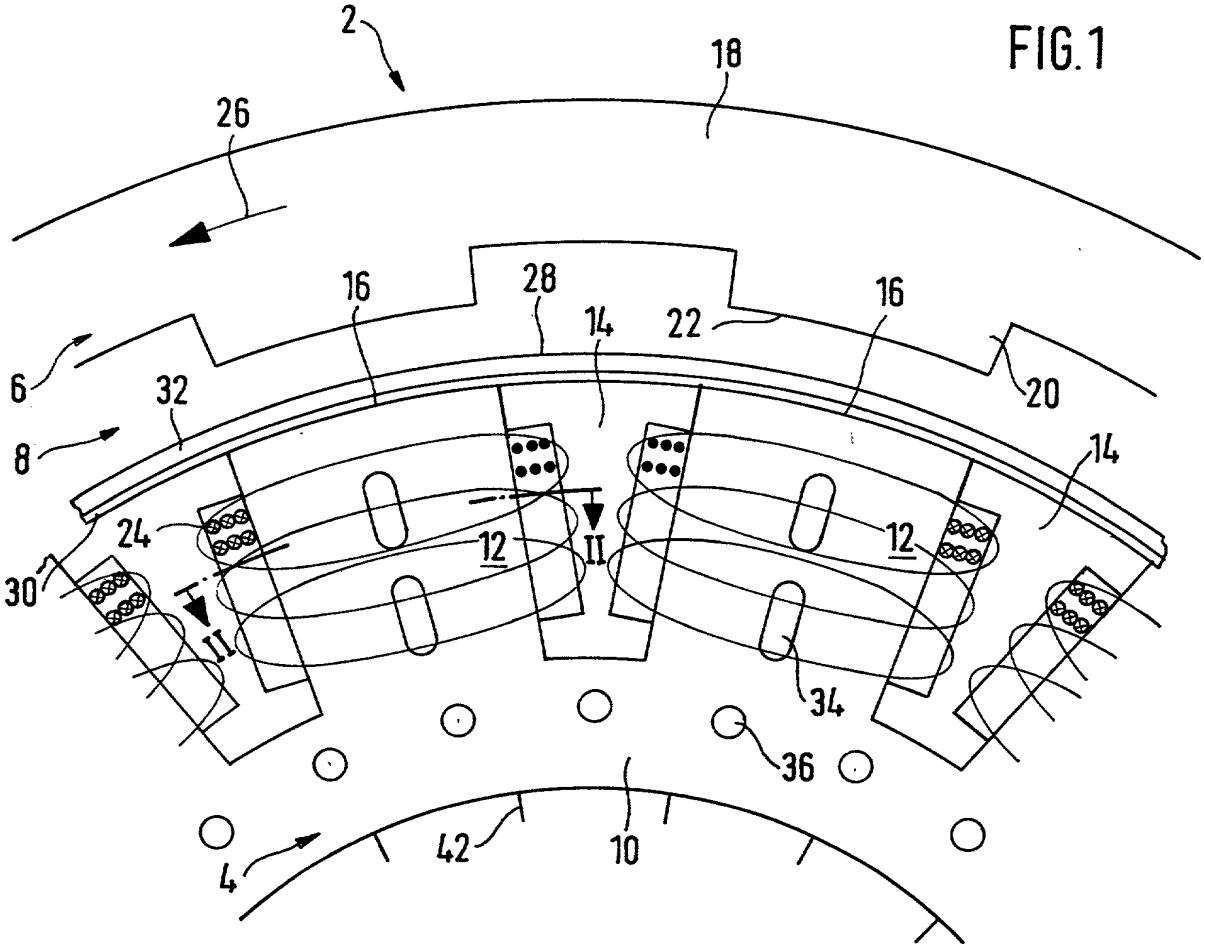
In Fig. 1 wurden die Statorpole 16 über die Spulen 24 nach oben hinaus bis an die innere Schicht 30 der Abdichtlage 28 forgesetzt. Die Ursprungsoffenbarung dafür findet sich beispielsweise in Fig. 3, aus der ganz deutlich ersichtlich ist, daß die Statorpole 12 bis nach oben an die Abdichtlage 28 hin ragen.

Es wird **beantragt**, die geänderte Zeichnungsseite zur Veröffentlichung vorzusehen.

T. Amann
Zusammenschluß Nr. 100

Anlage (3fach)
Zeichnungsseite mit Fig. 1 und 3

FIG.1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18
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16
28
14
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16
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12
II
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II
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42
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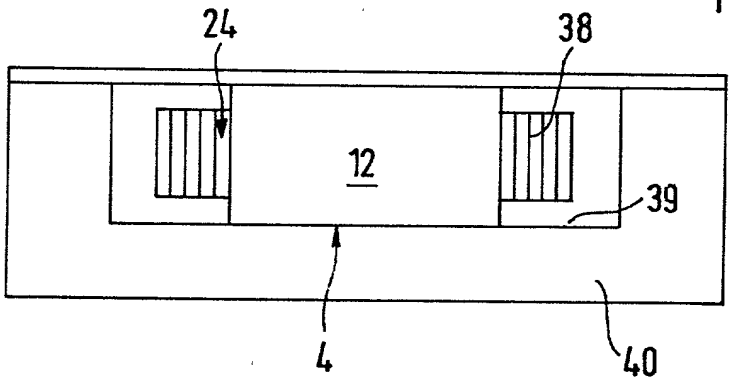
FIG.3


24
38
12
39
4
40

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: Peter EHRHART et al.

Intl. Appl. No.: PCT/EP00/07929

Intl. Filing Date: August 14, 2000

For: INDUCTION-TYPE ELECTRIC MACHINE

Art Unit: Unassigned

Examiner: Unassigned

Atty. Docket No.: 31812-178428

Customer No.

26694

PATENT TRADEMARK OFFICE

Submission Of Formal Drawings

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

With the assumption that the Request For Approval of Drawing Changes will be accepted, submitted herewith are 2 sheets of corrected formal drawings containing Figures 1-3.

Respectfully submitted,

Date: 2/20/02

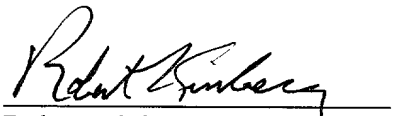


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FIG.1

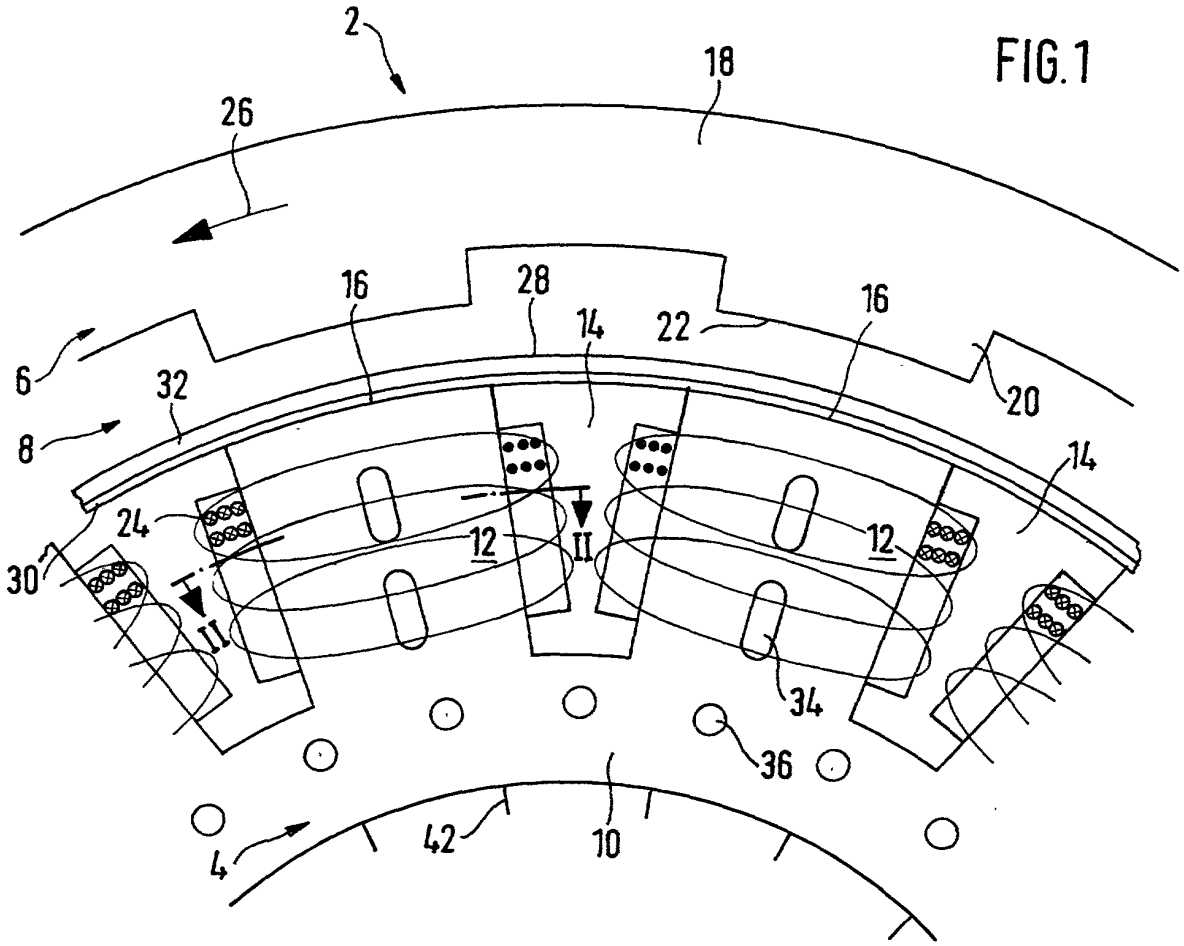


FIG.3

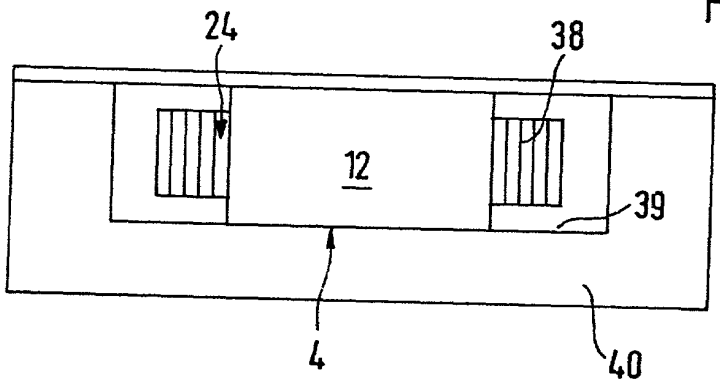
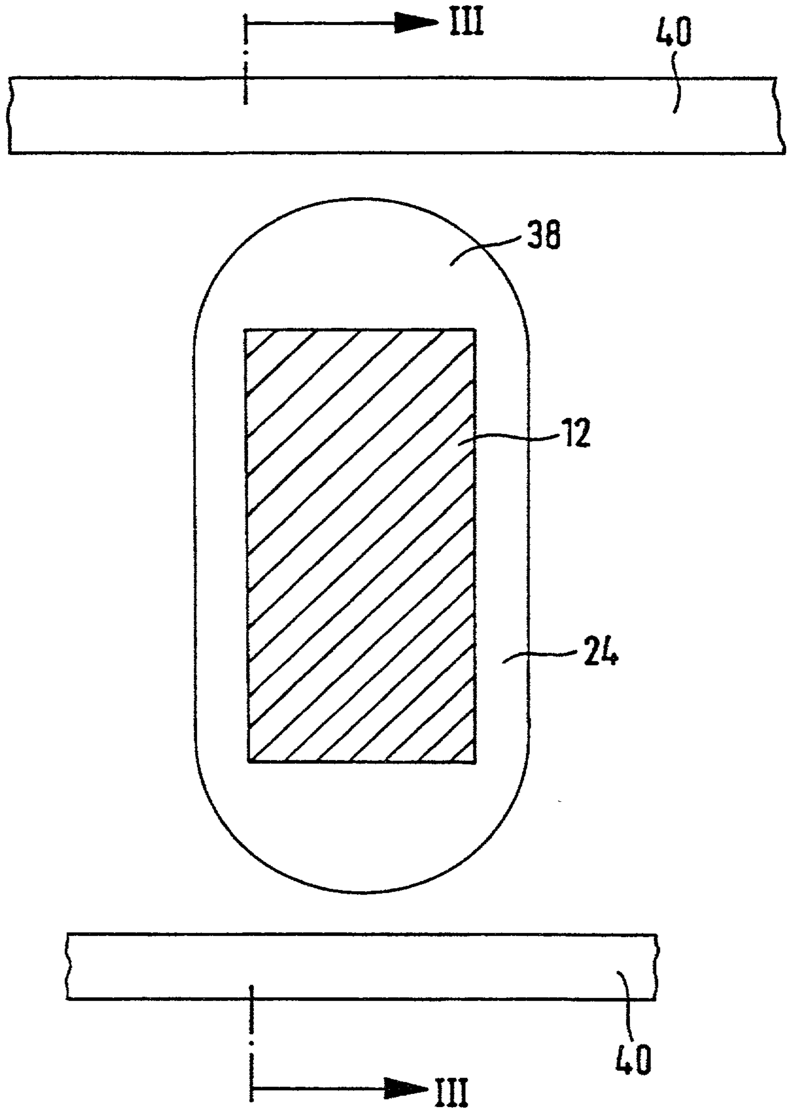


FIG. 2



3/prts

K 54 273/8–St

Reluctance Electric Machine

The invention relates to a reluctance electric machine comprising a stator part with stator teeth of magnetically conductive material that are provided with coil windings;
and a rotor part arranged coaxially with respect to the stator part and located opposite the stator part so as to leave free an air gap therebetween,
the rotor part having a number discrete poles of magnetically conductive material that project in the direction towards the stator part.

Reluctance electric machines differ from other electric machines in that they have no electromagnetic or permanent–magnetic excitation part. Reluctance electric machines operate by using the effect of magnetic attraction of magnetically conducting parts under the influence of magnetic flux flowing through the same. Both the stator and the rotor have distinctive magnetically conductive poles. The coil windings have current flowing therethrough such that they attract an adjacent rotor pole each. The current in the stator pole has to be turned off again at the proper time after attraction of the respective rotor pole, in order to release the rotor pole in running direction. For, if the coil current would continue to flow (irrespective of the direction of flow), continued attraction by the stator pole, i.e. a retroactive force, would result that would prevent further rotation of the rotor.

It is thus in the nature of reluctance electric machines that these are exploited basically half of the time only. This is why reluctance electric machines – assuming otherwise identical design parameters – normally achieve only about half of the torque values or power values in comparison with other electric motors.

It is the object of the invention to improve a reluctance electric machine of the type indicated at the outset towards higher values as regards permanent torque and permanent power.

To meet this object, the reluctance electric machine according to the invention is characterized in
that cooling with channelled coolant flow is provided at least for partial sections of the coil windings of the stator part.

Preferably, the coil windings are provided with an enclosure each. As an alternative, there are preferably several coil windings commonly provided with an enclosure each. In accordance with a particularly preferred embodiment, the stator part is provided with an enclosure in its entirety. In all of the cases mentioned, there may be provided, for the space enclosed by the enclosure, one or more coolant supplies and one or more coolant discharges.

As regards the term "projecting, discrete poles" in feature (c) of claim 1, it is to be pointed out furthermore that the portions between the discrete poles may also be filled with a non-magnetic material so that the rotor part is virtually smooth on the air gap side.

The invention teaches to make the cooling of the stator part considerably more efficient than with known reluctance electric machines. The electric machine thus can be subjected to considerably higher loads – permanently and not only for short periods, as before.

The statements further below will make clear that the channelling of the coolant flow according to the invention, in practical application, mostly has the effect that the stator part of the reluctance electric machine is provided with a sealing layer on the side facing the air gap. The result of the sealing layer is that the distance between the stator poles and the rotor poles across the air gap is greater than without provision of a seal-

ing layer. This means – with otherwise unchanged design parameters – a reduction of the magnetic flux between the respective pair of stator pole and rotor pole in consideration and thus a deterioration of the magnetic conditions of the electric machine. With the corresponding designs of the reluctance electric machine according to the invention, which have a sealing layer, this disadvantage is deliberately tolerated; according to the invention, the considerably more efficient cooling achieves a greater advantage than the deterioration of the magnetic conditions due to additional material in the air gap.

These restrictions are not applicable when the stator poles, by way of suitable enclosures, have individually associated cooling spaces or cooling channels that cover only the end face portions and do not project into the air gap.

Known reluctance electric machines also have already made use of cooling means. Known concretely are the non–specific blowing of air through the entire electric machine (stator part, air gap, rotor part) or cooling on the stator part side directed away from the air gap. In contrast thereto, the reluctance electric machine according to the invention employs direct or quasi–direct cooling of those portions where the heat losses arise in the first place. A first major portion of generation of heat losses are the coil windings (often referred to as "copper losses"; these are caused mainly by the passage of current). According to the invention, the coil windings are cooled directly by cooling medium flowing therealong. Even if the coil windings are cooled only in the spaces between the stator teeth or only in the spaces on the face side of the stator teeth (and not in both spaces), very efficient cooling is achieved since the material of the coil windings, which has good current conducting properties, also provides for good conduction of the heat losses to the portions cooled concretely. Another major place of generation of heat losses are the stator teeth (often referred to as "iron losses" in simplified manner; these losses are caused mainly by the continuous alternation between mag–

netization and demagnetization or remagnetization of the stator teeth). The described cooling operation by flow of cooling medium through spaces accommodating coil windings of the stator part, at the same time constitutes cooling of the stator teeth since – at least with many design types of the coil windings – the cooling medium flows in the spaces mentioned so as to reach the stator teeth and since the coil windings establishing physical contact with the stator teeth dissipate heat from the stator teeth by thermal conduction. Furthermore, the cooling medium usually flows along the stator back between the stator teeth; the stator back receives heat from the stator teeth by thermal conduction.

A preferred development of the invention provides that the stator teeth have internal flow passages for cooling medium. This provides for direct, particularly efficient internal cooling of the stator teeth. Furthermore, it is pointed out as preferred possibility according to the invention to provide in addition to, or instead of, the described internal cooling of the stator teeth, internal flow passages for cooling medium in the region of the stator part which are set back from the stator teeth.

It is expressly pointed out that the term "reluctance electric machine" used in the present application comprises both electric motors (conversion of electric energy to mechanical energy) as well as current generators (conversion of mechanical energy to electric energy). In addition thereto, it is expressly pointed out that the term "stator part" is not supposed to mean that the stator part cogently is to be non-moving, and that the term "rotor part" is not supposed to mean that the rotor part cogently is supposed to be a rotatable part of the electric machine. Rather, it is easily possible to provide the stator part (i.e. the part of the electric machine provided with coil windings) as rotating machine part and the rotor part as stationary, non-moving machine part. The inverse design, however, is usually more favorable since the current windings having current supplied thereto and, in case of the generator, discharged therefrom, are located on a stationary machine part, whereby sliding contacts

are avoided. In addition thereto, the possible embodiment is to be mentioned that both the stator part and the rotor part rotate at different speeds and/or different directions of rotation, in particular when they are connected to each other via a gear system or part of a gear system, e.g. a planetary gear system.

The electric machine according to the invention preferably is formed with electronic activation and deactivation of the coil winding currents. By means of a suitable sensor or on the basis of electric information from feeding the electric motor, the rotational relative position between stator part and rotor part is ascertained; the current through the coil windings is turned on and off again at the proper time each. Suitable electric circuits and suitable electronic components for realizing the described current control for electric motors and current withdrawal for generators, respectively, are known and need not be described here in more detail.

The reluctance electric machine according to the invention may be designed to have a – roughly speaking – cylindrical air gap (so that cooperating pairs of stator pole and rotor pole, so to speak, are "confronting " each other in radial direction) or – roughly speaking – an air gap located in a plane perpendicularly to the axis of rotation of the rotor part (so that cooperating pairs of stator pole and rotor pole, so to speak, are "confronting " each other in axial direction). It is possible in both cases to make use of several air gap portions, i.e. for example several cylindrical air gap portions on different diameters of the electric machine or several "planar" air gap portions axially beside each other; in both cases there is formed a sequence of stator part – rotor part – stator part – rotor part – stator part etc.

In a preferred embodiment of the invention, the stator part is provided with a sealing layer on the side facing the air gap. By means of the sealing layer, it is possible in particularly simple manner in terms of con-

struction to seal the spaces accommodating the coil windings in the direction towards the air gap in tight manner with respect to the cooling medium. For sealing the spaces on the face side of the stator teeth in the other directions so as to provide tightness with respect to the cooling medium, it is possible in particular to provide for each stator tooth a component part of U-shaped cross-section. These circumstances will be described in more detail further below in the description of a concrete embodiment.

In case of the – roughly speaking – cylindrical air gap, the sealing layer normally is cylindrical or substantially cylindrical. In case of the "planar" air gap arranged perpendicularly to the axis of rotation, the sealing layer normally is planar or substantially planar and, in a front view, has substantially the shape of a ring of a circle.

Preferably, the sealing layer has a first layer for fulfilling the sealing function and a second layer for taking up the forces acting on the sealing layer. The first layer may preferably by a plastics film. The second layer may preferably consist of plastics material, in particular fiber-reinforced plastics material (e.g. reinforced with carbon fibers). As regards the forces acting on the sealing layer, especially the forces due to excess pressure of the cooling medium and centrifugal forces due to rotation of the stator part (with a machine design with rotating stator part) should be mentioned. The thickness of the sealing layer is preferably 0.3 to 1.5 mm.

The reluctance electric machine according to the invention may use either liquid cooling medium or gaseous cooling medium. Liquid cooling medium as a rule leads to higher cooling efficiency.

In case of the design with – roughly speaking – cylindrical air gap, it is possible to select either a design with external rotor (the rotor part has its rotor poles located radially farther outside than the air gap) or a design with internal rotor (the stator part has its stator teeth located radially far-

ther outside than the air gap). In the former case, the rotor part often is of pot-shaped configuration in its entirety. The same holds for rotors having the afore-mentioned multiple air gap of cylindrical configuration.

Preferably, the stator part, on the side directed away from the rotor part, is designed such that the heat transfer is increased. This can be achieved by increasing the surface area or also and in addition by the generation of turbulent flow. Heat dissipation ribs are indicated as a concrete example in this respect. On the "rear side" of the stator part, cooling can be effected either with the same cooling medium as the one flowing through the flow passages associated with the coil windings. As an alternative, it is also possible to use a different cooling medium on this "rear side", e.g. cooling air supplied by a fan or air without forced movement.

Preferably, the coil windings in the winding head portions located on the face side of the stator teeth, are provided with flow passages for the cooling medium that are left free between coil winding conductors. While the coil windings in the grooves between the stator teeth normally should be wound as densely packed as possible for electric and magnetic reasons, in particular for reducing losses, it is more tolerable in the winding head portions located on the face side of the stator teeth to arrange either individual coil winding conductors in spaced apart manner or, as a further example, to leave small distances between winding layers, e.g. in axial direction. The measures mentioned serve to intensify the heat transfer in the winding head portions mentioned.

In a preferred development of the invention, the coil windings of the stator part are in the form of individual coils that are not interlinked with respect to the magnetic flux. This is conceivable, for example, such that a prefabricated individual coil is slid onto each individual stator tooth. The individual coils either are electrically connected to each other di-

rectly (e.g. in series or in parallel) or are connected individually or in groups to the electronic current control.

Preferably, there are provided a first, internal cooling circuit for circulating the cooling medium through the flow passages described, and a second, external cooling circuit for circulating another cooling medium, with the external cooling circuit being connected to the internal cooling circuit via a heat exchanger. The cooling medium in the internal cooling circuit and the additional cooling medium in the external cooling circuit may be the same cooling media. However, particularly preferred is a design in which the cooling medium in the internal cooling circuit is electrically non-conductive oil and the additional cooling medium in the external cooling circuit is a different cooling liquid, in particular water. As a rule, there is provided an additional heat exchanger via which the external cooling circuit dissipates its heat to the environment.

Preferably, the internal cooling circuit has a circulation pump of its own. The internal cooling circuit and the heat exchanger preferably are integrated in terms of space on the reluctance electric machine. The external cooling circuit may, but does not have to, extend a distance away from the reluctance electric machine.

The described design with two coupled cooling circuits allows the necessary volume of cooling medium in the internal cooling circuit to be kept low. This is favorable since, as a general rule, special cooling medium has to be employed here which may establish contact with the portions of the electric machine subjected to the coolant, without disturbance being caused thereby. These specific cooling media, e.g. electrically non-conductive cooling oil, are comparatively expensive.

A concrete embodiment for an electric motor cooling means with internal and external cooling circuits is described in German patent application 196 51 119.4. The total contents of this laid open publication is made

part of the instant application by making reference thereto. Preferably, the reluctance electric machine according to the invention has one or more features that are disclosed in said German patent application 196 51 119.4.

The invention and further developments of the invention shall be elucidated in more detail in the following by way of an embodiment shown schematically in the drawings in which

Fig. 1 shows a reluctance electric machine in a cross-sectional view (which is transverse to the axis of rotation of the machine);

Fig. 2 shows a part of reluctance electric machine of Fig. 1 in a sectional view along the line II-II in Fig. 1 (which is in circumferential direction and then developed in the drawing plane;

Fig. 3 shows part of the reluctance electric machine of Fig. 1 in a sectional view along the line III-III in Fig. 2 (which is a planar section containing the axis of rotation).

Fig. 1 illustrates most clearly a stator part 4 located radially farther inside, a rotor part 6 located radially farther outside, and therebetween a - roughly speaking - cylindrical air gap of a reluctance electric machine, which in the following will be briefly referred to as "electric machine 2" only.

The stator part 4 of the electric machine 2 has a base portion 10 located radially farther inside and having stator teeth 12 projecting radially outwardly therefrom. Progressing in circumferential direction, there is provided a series of stator teeth 12. A groove 14 is provided between two adjacent stator teeth 12 each. The stator teeth 12 are slightly rounded at the top in the form of a circular curve. The radially outer ends of the sta-

tor teeth 12 constitute stator poles 16 which are all located on a common cylinder surface.

The stator part 4, as described hereinbefore, consists with its base portion 10 and its stator teeth 12 of stator sheets which are stacked successively in the direction perpendicularly to the drawing plane of Fig. 1 and are connected to each other e.g. by adhesive bonding.

Located farther radially outside, the rotor part 6 has a base portion 18 from which project discrete rotor poles 20 in the direction towards the air gap 8. The rotor pole surfaces 22 – as measured in circumferential direction – are substantially as long as the stator pole surfaces 16.

Both the stator part 4, as described so far, along with its base portion 10 and its stator teeth 12, and the rotor part 6 along with its base portion 18 and its rotor poles 20, consist of magnetically conducting material.

Each stator pole 12 has a coil 24 arranged thereon. Each stator tooth 12 has a winding wound in opposite direction to that of its two neighboring stator teeth 12.

The illustrated embodiment of the electric machine 2 has a rotatable external rotor part 6 whose axis of rotation is indicated with an arrow 26. The stator part 4 is non–rotatable. In the rotational relative position of rotor part 6 relative to the stator part 4, as illustrated in Fig. 1, the windings 24 of all stator teeth 12 are activated. As soon as the rotor part 26 has moved a distance further in counterclockwise direction, i.e. when are rotor poles 20 are each substantially opposite a stator pole 16, the current is turned off for all windings 24. The rotor part 6 continues to rotate due to inertia, and the currents through the coils 26 are turned on again as soon as each rotor pole 20 is arranged substantially centrally between two adjacent stator poles 16.

A sealing layer 28 is placed cylindrically around the outside of the stator pole areas 16 and is attached to the stator part 4. The sealing layer 28 consists of a radially inner, first layer 30 for fulfilling a sealing function and a radially outer, second layer 32 for taking up the forces acting on the sealing layer 28. By means of the sealing layer 28, the groove spaces located between two adjacent stator teeth 12 each are closed radially towards the outside so as to provide tightness with respect to the cooling medium.

Fig. 1 shows furthermore axially extending flow passages 34 inside the stator teeth 12 as well as axially extending flow passages 36 inside the base portion 10 of the stator part 4.

Fig. 2 shows that he coils 24 are "thicker" in the winding head portions 38 located on the face side of the stator teeth 12 than in the groove portions 14. In the winding head portions 38, the individual layers of the respective coil 24 are arranged at a small spacing so that so to speak internal flow passages are formed there.

Fig. 3 illustrates how flow passages 39 are formed that are closed on the face side of the stator teeth 12 and extend in circumferential direction. The stator part 4 has mounted thereon an annular component 40 of U-shaped cross-section. Component 40 consists e.g. of plastics material. The legs of component 40 have the sealing layer 28 resting thereon on the radial outside thereof.

In the groove portions 14 and flow passages 39, respectively, there is provided e.g. electrically non-conducting oil as cooling medium. The cooling medium can enter one of the flow passages 39, e.g. at a specific location. It then flows in circumferential direction in this flow passage 39 and cools the winding head portions 38 on this face side of the stator

part 4. The cooling medium can pass over, through the groove flow passages 14, to the other circumferential flow passage 39, thus cooling in the groove flow passages 14 the regions of the coils 24 located there. The cooling medium then flows in the other circumferential flow passage 39 and is discharged at such a location that the entire stator part 4 has been cooled. As illustrated by the drawing figures as well, the flow of the cooling medium establishes contact with the stator teeth 12 at numerous locations and, at the bottom of the respective groove 14, also with the base portion 10 of the stator part 4, so that heat is dissipated from the iron components of the stator part 4 as well.

If desired, the flow passages 34 and/or 36 may be provided and have cooling medium flowing therethrough, whereby still more intensive cooling of the iron components of the stator part 4 results. In an embodiment having no U–shaped component, the stator part 4, on the inner circumferential area thereof, may be provided with ribs 42 projecting radially inwardly, so that better heat dissipation conditions are present there, e.g. to the liquid cooling medium or, in case of a corresponding design of the construction, also to a gaseous cooling medium, in particular air.

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Translation of the Annex to the IPER

Claims

1. A reluctance electric machine comprising
   (a) a stator part (4) with stator teeth (12) of magnetically conductive material that are provided with coil windings (24);
   (b) and a rotor part (6) arranged coaxially with respect to the stator part (12) and located opposite the stator part (12) so as to leave free an air gap (8) therebetween,
   (c) the rotor part (6) having a number of discrete poles (20) of magnetically conductive material that project in the direction towards the stator part (12),
   (d) that cooling with channelled coolant flow is provided at least for partial sections of the coil windings (24) of the stator part (12),
   (e) that the stator part (4) is provided with a sealing layer (26) on the side facing the air gap (8),
   characterized in
   (f) that a liquid cooling medium is provided, and
   (g) that the sealing layer (28) has a first layer (30) for fulfilling the sealing function and a second layer (32) for taking up the forces acting on the sealing layer (28).

2. A reluctance electric machine according to claim 1, characterized in that the coil windings (24) are provided with an enclosure each.

3. A reluctance electric machine according to claim 1, characterized in that several coil windings (24) are commonly provided with an enclosure each.

4. A reluctance electric machine according to claim 1, characterized in that the stator part (4) is provided with an enclosure (28, 40) in its entirety.

5. A reluctance electric machine according to any of claims 2 to 4, characterized in that there are provided several coolant supply means and several coolant discharge means for the enclosure.

6. A reluctance electric machine according to any of claims 1 to 5, characterized in that the stator teeth (12) have internal flow passages (34) for the cooling medium.

7. A reluctance electric machine according to any of claims 1 to 6, characterized in that, with respect to the axis of rotation of the electric machine (2), the stator part (4) is arranged farther radially inside and the rotor part (6) with its rotor poles (20) is arranged farther radially outside.

8. A reluctance electric machine according to any of claims 1 to 6, characterized in that, with respect to the axis of rotation of the electric machine, the stator part with its stator teeth is arranged farther radially outside and the rotor part is arranged farther radially inside.

9. A reluctance electric machine according to any of claims 1 to 8, characterized in that the stator part (4), on the side directed away from the rotor part (6), has a design (42) for increasing the heat dissipation.

10. A reluctance electric machine according to any of claims 1 to 9, characterized in that the coil windings (24), in the winding head portions (38) located on the face side of the stator teeth (12), are formed with flow passages for the cooling medium that are left free between coil winding conductors.

11. A reluctance electric machine according to any of claims 1 to 10, characterized in that the coil windings (24) of the stator part (4) are designed as individual coils that are not interlinked with respect to the magnetic flux.

12. A reluctance electric machine according to any of claims 1 to 11, characterized in that a first, internal cooling circuit for circulating the cooling medium and a second, external cooling circuit for circulating another cooling medium are provided, the latter being connected to the internal cooling circuit via a heat exchanger.

13. A reluctance electric machine according to claim 12, characterized in that the internal cooling circuit has a circulation pump of its own.

14. A reluctance electric machine according to claim 12 or 13, characterized in that the internal cooling circuit and the heat exchanger are integrated in terms of space on the reluctance electric machine.

Abstract

A reluctance electric machine comprising: (a) a stator part (4) with stator teeth (12) of magnetically conductive material that are provided with coil windings (24); (b) and a rotor part (6) arranged coaxially with respect to the stator part (12) and located opposite the stator part (12) so as to leave free an air gap (8) therebetween; (c) the rotor part (6) having a number of discrete poles (20) of magnetically conductive material that project in the direction towards the stator part (12), characterized in (d) that cooling with channelled coolant flow is provided at least for partial sections of the coil windings (24) of the stator part (12).

FIG.1

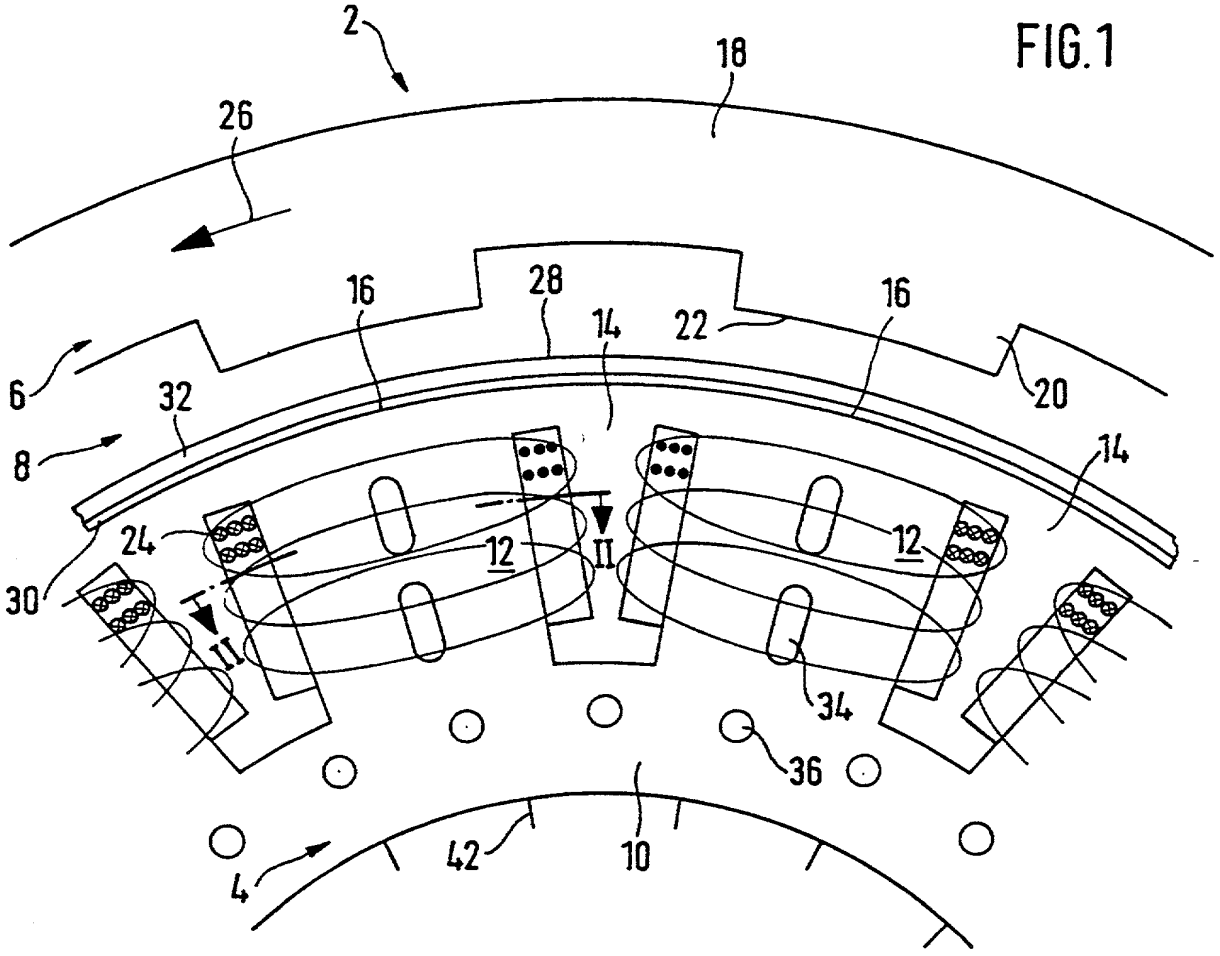


FIG.3

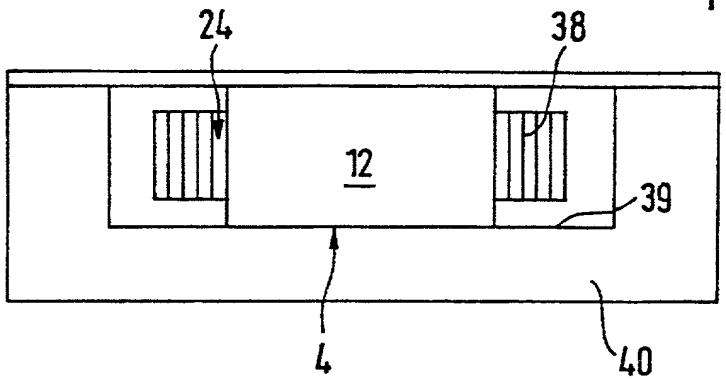
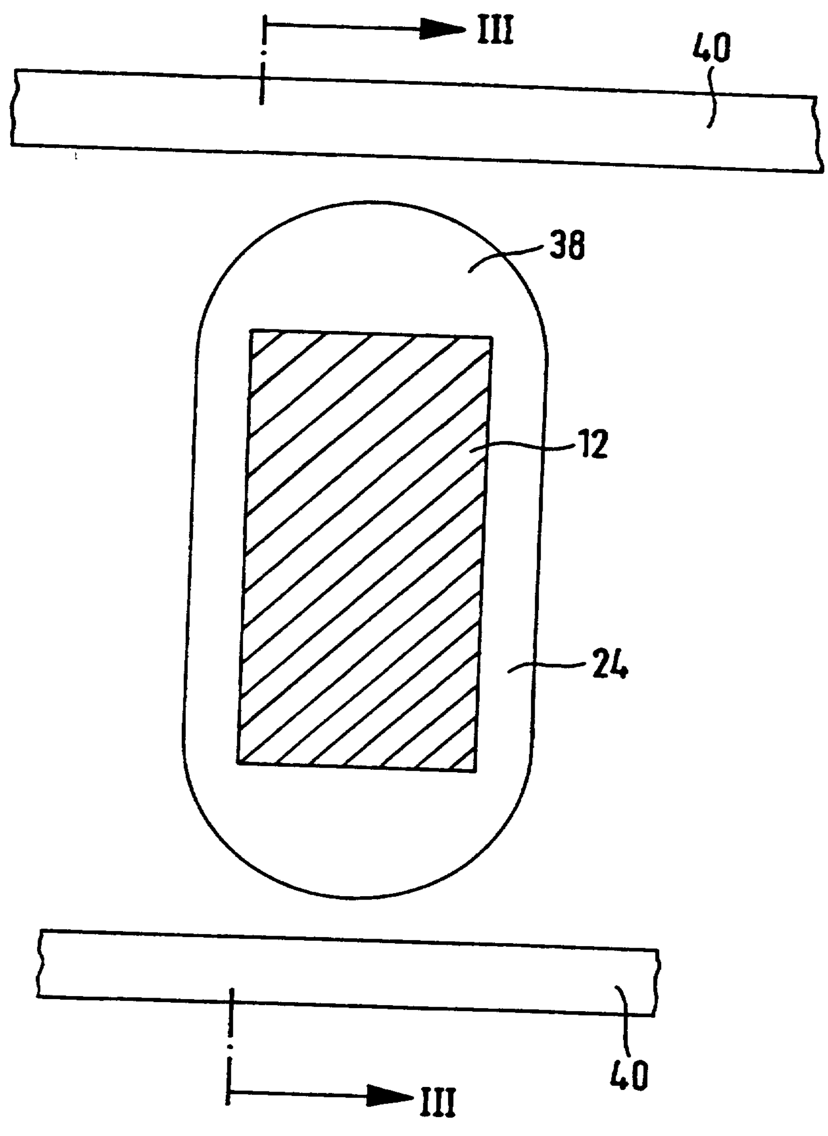


FIG. 2



Attorney Docket: _____

DECLARATION FOR UNITED STATES PATENT APPLICATION,
POWER OF ATTORNEY, DESIGNATION OF CORRESPONDENCE ADDRESS

As a below named inventor, I hereby declare that my residence, post office address and citizenship are as stated below next to my name, and that I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled Reluctance Electric Machine, the specification of which

[ ] is attached hereto.

[ ] was filed on _____ as Application No. _____ and was amended on _____ [if applicable].

[X] was filed under the Patent Cooperation Treaty on Aug. 14, 2000, as Application No. PCT/EP00/07929, the United States of America being designated.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56.

I hereby claim the benefit under Title 35, United States Code, § 119(e) of any United States Provisional Application listed below: United States Provisional Application No. _____, filed _____

I hereby claim foreign priority benefits under Title 35, United States Code, § 119 of any foreign application(s) for patent, utility model, design or inventor's certificate listed below and have also identified below any foreign application(s) for patent, utility model, design or inventor's certificate having a filing date before that of the application(s) on which priority is claimed:

Prior Foreign Application(s)			Priority Claimed
Number	Country	Date Filed	Yes XXX
199 39 598.5	Germany	August 20, 1999	

I hereby appoint the following attorneys and agents to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: George H. Spencer (Reg. No. 18,038), Robert J. Frank (Reg. No. 19,112), Norman N. Kunitz (Reg. No. 20,586), Gabor J. Kelemen (Reg. No. 21,016), John W. Schneller (Reg. No. 26,031), Marina V. Schneller (Reg. No. 26,032), Robert Kinberg (Reg. No. 26,924), Allen Wood (Reg. No. 28,134), Ashley J. Wells (Reg. No. 29,847), James R. Burdett (Reg. No. 31,594), Michael A. Gollin (Reg. No. 31,957), Catherine M. Voorhees (Reg. No. 33,074), G. Abe Zachariah (Reg. No. 38,366), Julie A. Petruzzelli (Reg. No. 40,769), Catherine A. Ferguson (Reg. No. 40,877), Clint A. Gerdine (Reg. No. 41,035), Michael P. Leary (Reg. No. 41,144), Michael A. Sartori (Reg. No. 41,289), and Charles C. P. Rories (Reg. No. 43,381)) all at Suite 1000, 1201 New York Avenue, N.W., Washington, D.C. 20005-3917, Telephone: (202) 962-4800, Telefax: (202) 962-8300. Address all correspondence to VENABLE, Post Office Box 34385, Washington, D.C. 20043-9998.

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under §1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Rev. 3/99, DC2-124151